Agri Articles
(e-Magazine for Agricultural Articles)
Volume: 05, Issue: 05 (SEP-OCT, 2025)
Available online at http://www.agriarticles.com
©Agri Articles, ISSN: 2582-9882

Enhancing Occupational Wellness through Ergonomically Improved Intercultural Tools among Tribal Farmers in Meghalaya

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Agriculture forms the backbone of the rural economy in Meghalaya, with the predominant farming community comprising various tribal groups who largely depend on smallholder cultivation systems. These farmers engage intensively in manual labour due to the challenging topography characterized by hills, slopes, and fragmented fields, as well as complex cropping patterns suited to local agroecological conditions. Key farming activities such as weeding, bed preparation, and field clearing demand prolonged periods of physically strenuous work often performed in awkward postures, which considerably elevates the risk of chronic health problems (Shivakumar et al., 2023).

Women farmers constitute most of the agricultural workforce in Meghalaya, undertaking the bulk of labor-intensive tasks. Unfortunately, the tools they commonly use (hand weeders, hand spades, and locally fabricated daos) are often poorly adapted to their physiological dimensions and the specific field conditions, especially in waterlogged or sloped terrains. This mismatch results in excessive drudgery, increased exposure to musculoskeletal disorders (MSDs), repetitive strain, and work-related fatigue. Such health burdens threaten not only individual well-being but also agricultural productivity and the socio-economic stability of farming households (Singh et al., 2020, 2022; Singh & Karmakar, 2021).

In recent years, concerted research and extension initiatives have introduced ergonomically improved intercultural implements such as Cono weeders, U-blade weeders, wheel hoes, garden rakes, and innovative grass slashers designed specifically for Meghalaya's agro-climatic and socio-cultural contexts. These improved tools aim to reduce physical workload and drudgery while enhancing operational efficiency and worker safety. Evidence from field trials and ergonomic assessments globally reinforces the value of such interventions in promoting sustainable, gender-sensitive agricultural systems that align well with the capabilities and needs of tribal farm labourers in northeastern India.

Improved Farm Tools

The challenges of manual weeding and intercultural operations in Meghalaya's hilly and water-logged conditions were addressed through trials with a range of improved farm tools adapted to local needs.

- **Hand Weeding:** Traditionally, paddy weeding is performed manually by three persons plucking weeds. This method is laborious and characterized by a very low effective field capacity of only 0.0075 hectares per hour per person. This intense physical demand leads to fatigue, back pain, and hand injuries due to repetitive bending and prolonged squatting (Tamilselvi et al., 2020; Singh et al., 2022).
- **Cono Weeder:** Tested in lowland rice fields, the Cono weeder is manually operated by a single person using a forward-pulling and pushing motion. It demonstrated an effective field capacity of 0.018 hectares per hour, more than twice that of manual weeding.

Farmers were impressed by the implement's ease of use and time-saving potential. Importantly, it reduced physical strain by minimizing bending postures, thus effectively lowering drudgery (Shakya et al., 2016). Farmer feedback indicated high receptivity, with expressed interest in purchasing the tool.

- **U-Blade Weeder:** Operating with one person applying pulling action, this tool performed well in lowland fields with less irrigation or no standing water, achieving an effective field capacity of 0.0081 hectares per hour. It eases strain on joints and supports better posture compared to traditional methods.
- **Garden Rake and Hoe:** These tools facilitate weed collection and intercultural operations in ginger, turmeric, and kitchen gardens. The garden rake helps reduce hand injuries and time spent collecting loose weeds, while the garden hoe, being lighter than the locally made spade, is well-suited for narrow spaces.
- **Grass Slasher:** This tool significantly eases the clearing of dense field vegetation by enabling a more upright posture and swinging action that cuts vegetation on both sides of the blade, thereby reducing back strain compared to traditional daos.
- **Hand Fork, Straight Blade, U-type, and V-type Blade Weeders:** These implements target specific weed types and intercultural tasks, decreasing the need to bend excessively and allowing easier removal of tap-rooted or thorny weeds. The V-type blade additionally serves dual functions in weeding and earthing-up of crops like maize and ginger.
- **Wheel Hoe:** Useful for loosening soil and weeding, especially in loose soils, this implement simplifies intercultural operations and assists in opening furrows for vegetable crops (Praveen et al., 2025).

Together, these tools represent a portfolio of ergonomic solutions that address diverse intercultural challenges faced by tribal farmers, enhancing efficiency and reducing the physical toll.

Figure 1. Weeding with different methods in paddy field (a. weeding by hand, b. weeding by Cono weeder, c. weeding by U-blade weeder, and d. field condition after weeding)

Figure 2. Weeding with different methods under upland conditions (a. Hand wedding in maize, b. Weeding with a spade in maize, c. wedding with wheel hoe in maize, and d. Power weeding in beans)

Figure 3. Weeding with a spade in a pineapple farm

Drudgery and Health Outcomes

Manual agricultural operations, particularly hand weeding in waterlogged and uneven terrains, expose workers to significant ergonomic hazards. Scientific assessments in Meghalaya have revealed that manual weeding requires prolonged squatting and repetitive motions that impose high cardiovascular and musculoskeletal strain. Women, especially older individuals, report chronic lower back pain, hand injuries, including rashes from weed irritation, and acute fatigue due to the sustained awkward postures encountered during such tasks (Borah & Borah, 2020).

Physiological monitoring during manual weeding activities confirmed elevated heart rates and energy expenditures consistent with strenuous labour, further corroborated by field observations documenting work-related musculoskeletal disorders (MSDs) prevalence exceeding 70% among female farm workers in similar settings. This occupational stress is compounded by harsh working conditions, including intense sun exposure, insect bites, and risks of injuries from sharp tools, sometimes resulting in serious health consequences such as a prolapsed uterus due to frequent bending and squatting (Borah & Borah, 2020).

The adoption of improved ergonomic tools, such as the Cono and U-blade weeders and wheel hoes, has been linked with significant reductions in reported discomfort, heart rate, and energy consumption. They enable a more upright working posture, reduce bending movements, and decrease repetitive strain. Such ergonomic improvements contribute to lowering the incidence and severity of MSDs, allowing for longer and safer engagement in fieldwork without compromising health (Borah & Borah, 2020). Furthermore, improved implements have positively influenced labour participation rates among women by making farm work less physically taxing and more manageable.

Mechanized and Power-Assisted Weed Control Technologies

While manually operated ergonomic tools constitute a major advance, smallholder farmers in Meghalaya also stand to benefit from mechanized technologies adapted to hilly terrain constraints (Singh et al., 2022). Small engine-powered weeders, equipped with petrol or diesel engines ranging from 2 to 8 horsepower, have been developed to offer manageable, lightweight options for terraced and uneven slopes. These machines typically feature compact frames and adjustable handles to accommodate rugged terrain, employing rotary blade or tine attachments that effectively uproot weeds while minimizing crop damage. Models such as the Singh Power SP 1200, weighing approximately 55 kg, have gained recognition for balancing portability with power suitable for hill farming conditions. They have the potential to substantially reduce manual labour and enhance timely weed management, which is critical to maintain productivity. Battery-operated weed control devices present an environmentally sustainable alternative, utilizing lithium-ion batteries paired with brushless DC motors to provide quiet, fuel-free operation. Their lightweight design and ease of handling render them highly suitable for sensitive ecosystems and small-scale farms typical of tribal Meghalaya. These machines demonstrate high weeding efficiency over 90% in some trials and provide precise weed control with lower operator fatigue and emissions. Such mechanized tools complement manual ergonomic implements by expanding the choice of weed management solutions available to farmers under diverse geographic and economic constraints.

Discussion and Way Forward

The integration of ergonomically designed farm tools among tribal farmers in Meghalaya offers a pathway toward enhanced occupational wellness, agricultural productivity, and social equity. Despite the clear benefits demonstrated through field trials and ergonomic assessments, widespread adoption is constrained by several factors. These include limited awareness and technical knowledge about improved implements, financial limitations, cultural preferences for traditional practices, and accessibility challenges in remote regions. To overcome these barriers, a multipronged approach is essential. Inclusive design processes that actively engage farmers, especially women, in the selection and adaptation of tools can

enhance acceptance and ensure that ergonomic interventions address practical needs. Extension services, both formal and informal, must prioritize demonstrations and training focused on the health and productivity advantages of improved implements. Policy frameworks should further support subsidized distribution of women-friendly tools, promote local manufacturing to boost affordability and customization, and integrate ergonomic considerations into broader agricultural development strategies. Investment in research and development, including the use of digital human modelling and AI-driven ergonomic risk assessments, can refine tool designs and optimize operator comfort. Such concerted efforts will foster sustainable agricultural development that empowers tribal communities, reduces the health burdens of farm labour, and promotes gender-equitable participation.

Conclusion

In conclusion, the adoption of ergonomically improved intercultural farm tools profoundly enhances occupational wellness among tribal farmers in Meghalaya. By effectively lowering drudgery, minimizing musculoskeletal risks, and improving field capacity, these tools contribute to safer, more efficient farm operations. The combined use of manual ergonomic implements and mechanized weeders offers a comprehensive suite of options adaptable to the diverse terrain and cropping systems of the region. Bridging knowledge gaps through targeted extension, incentivizing local tool production, and embedding ergonomic priorities in agriculture policy will accelerate the transition toward resilient and equitable farming systems. Ultimately, such measures promise to secure healthier livelihoods and sustainable agricultural productivity for marginalized tribal communities in northeastern India.

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